JACOBS

Appendix A11.6: SuDS and Water Quality

1 Introduction

Scope

1.1.1 This appendix provides the following additional information on the operational Sustainable Drainage Systems (from herein referred to as SuDS) associated with the proposed scheme:

- description of existing drainage conditions;
- A9 Dualling SuDS design principles, and project specific departures from these principles;
- proposed SuDS components and management trains, and justification for their adoption;
- proposed SuDS outfall locations and discharge rates, and justification for their adoption;
- indicative SuDS maintenance requirements;
- proposed attenuation and restricted discharge rates; and
- water quality assessments in accordance with the Design Manual for Roads and Bridges (DMRB) HD45/09 (Highways Agency et al., 2009) and SEPA Regulatory Method (WAT-RM-08) Sustainable Urban Drainage Systems (SUDS or SUD Systems) (SEPA, 2017).

1.1.2 Temporary SuDS measures to be adopted during the construction of the proposed scheme are discussed within Appendix A5.1 (Construction Information). The impact assessment, informed by the results of water quality assessments, is presented in Appendix A11.7 (Impact Assessment).

Background

1.1.3 The primary purpose of SuDS is to provide a drainage solution which mimics the way that the natural hydrological cycle manages precipitation from interception, attenuation and transportation prior to eventual discharge into the ground or to a surface watercourse. SuDS are a legal requirement for discharges from road schemes under the Water Environment Water Services (Scotland) Act 2003 and the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended), and are therefore inherent in the design of the proposed scheme.

1.1.4 The four overarching pillars of SuDS design, of which any proposed SuDS scheme should aim to provide benefits to, are:

- water quality;
- water quantity;
- biodiversity; and
- amenity.

1.1.5 This appendix specifically considers the water quality and water quantity aspects embedded within the proposed SuDS design. Amenity and biodiversity aspects have been considered and are discussed within Appendix A13.6 (SuDS Design Principles).

2 Existing Conditions

Site Description

2.1.1 The study area for the proposed scheme is characterised by the flat topography of the River Tay floodplain and the adjacent steep hillsides of the lower Grampian Mountains. The proposed scheme drains entirely into the River Tay (WF06) catchment via numerous minor tributaries which are crossed by the proposed scheme. The sub-catchments in which the proposed scheme is located are predominantly rural with the existing A9 representing the main urban influence on catchment hydrology.

2.1.2 The hydrogeology of the study site is characterised by highly permeable alluvium and river terrace deposits underlying the River Tay floodplain, and low permeability glacial till and metamorphic bedrock on the adjacent hillsides. Ground Investigation (GI) data, including groundwater monitoring, indicates that groundwater levels are typically near surface (<3m below ground level) across the River Tay floodplain.

2.1.3 Further information on the hydrology and hydrogeology of the study area is provided within Appendix A11.2 (Surface Water Hydrology) and Chapter 10 (Geology, Soils, Contaminated Land and Groundwater) respectively.

Existing Drainage

2.1.4 The existing A9 is predominantly drained via a network of kerbs and gullies which discharge untreated and un-attenuated runoff into each minor watercourse crossed by the road. There are sections of filter drains which are understood to have been installed as part of maintenance or localised upgrading works. No drawings or schematics of the existing drainage networks have been identified, therefore assumptions made on the existing drainage are based on site surveys and topography.

2.1.5 The existing runoff rates from the proposed development footprint are discussed within paragraphs 3.1.30 to 3.1.35, and are detailed in Table 3.

3 Proposed Scheme

3.1.1 The mainline carriageway of the proposed scheme will incorporate 12 drainage catchments and outfalls (labelled A1 to H). The proposed side roads will incorporate 14 drainage catchments and outfalls, though due to the nature of the drainage proposals and assessment methods adopted, these are discussed collectively.

3.1.2 The SuDS management trains and outfall locations for the mainline carriageway of the proposed scheme are detailed in Table 1. SuDS treatment for the proposed side roads is discussed in paragraph 3.1.18. The locations of the proposed mainline SuDS components and drainage catchments are shown on Figure 11.4.

SuDS Design Principles

3.1.3 The following specific SuDS Design Principles, relevant to water quality and water quantity aspects, have been agreed amongst relevant stakeholders (including SEPA, local authorities and SNH) for the A9 Dualling Programme:

- SuDS should not be developed within the functional floodplain. Where this is unavoidable, SuDS should be protected from inundation during the 3.33% AEP (30-year) event and compensatory flood storage should be provided for any loss of floodplain storage during the 0.5% AEP (200-year) event.
- Two levels of SuDS treatment should be provided for all mainline drainage catchments (it is noted that the preference is for two levels of conventional SuDS and proprietary SuDS may only be considered a level of treatment in constrained sites).
- Surface water discharges should not result in any deterioration of water quality or hydrogeomorphological effects in the receiving watercourses.
- Cuttings, and hence SuDS basins, should avoid intercepting groundwater where this may result in the dewatering of groundwater or watercourses.

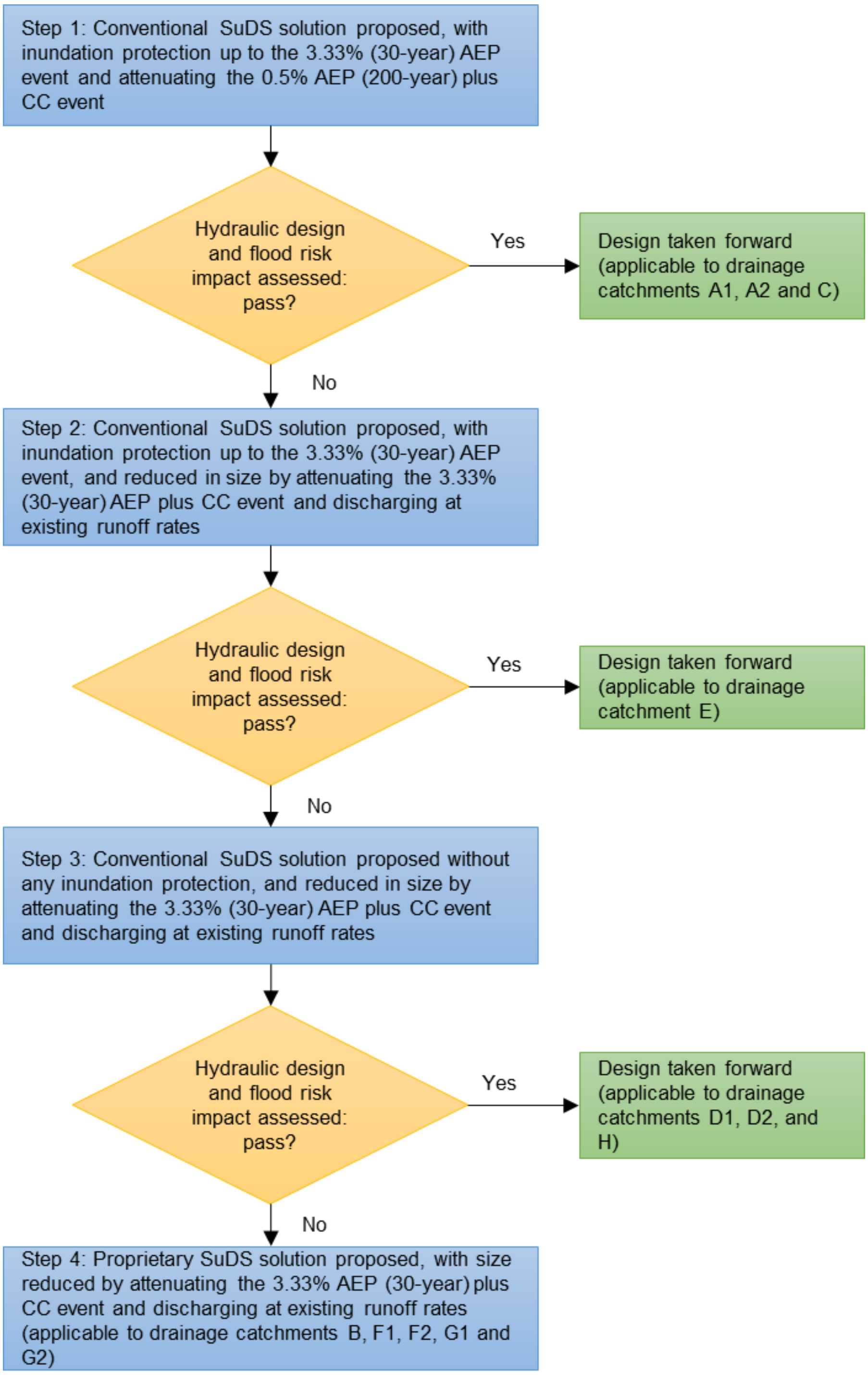
3.1.4 Standards for attenuation have not implicitly been agreed, nonetheless it has generally been accepted that the 0.5% AEP (200-year) plus climate change (CC) event should be attenuated where possible in line with the flood risk design standards.

Project Specific SuDS Departures

3.1.5 As described in Appendix A11.3 (Flood Risk Assessment), the proposed scheme is largely located within the functional floodplain of the River Tay. This has constrained the adoption of a second level of SuDS treatment, from both a flood risk, environmental and hydraulic performance perspective, on drainage catchments B, D1, D2, E, F1, F2, G1, G2 and H.

3.1.6 Diagram 1 details the decision process which has been followed in determining the preferred SuDS options to be adopted within these constrained catchments. The specific departures from the SuDS design principles (from herein referred to as 'SuDS Departures') are discussed in more detail below.

Diagram 1: Decision flow diagram for assessing options for second levels of SuDS when located within the functional floodplain



SuDS Departure 1: Maintaining Existing Discharge Rates & 3.33% AEP Attenuation Volume

3.1.7 Where SuDS components are located within the functional floodplain (drainage catchments B, D1, D2, E, F1, F2, G1, G2 and H), disproportionate impacts on water quantity (flood risk) through the loss of floodplain storage have been reduced by downsizing secondary SuDS components. Principally, a reduced standard of attenuation has been adopted which includes:

- attenuation of the 3.33% AEP (30-year) plus climate change (CC) rainfall event; and
- discharge rates based on existing QMED (50% AEP), accounting for the impermeable area associated with the existing A9.

3.1.8 Using this reduced standard has enabled SuDS components to be reduced in size, typically in the region of 50%, thereby providing overall water quantity benefits through minimising flood risk impacts whilst also maintaining existing drainage conditions. Further detail on this departure, including an assessment of pre- and post-development runoff rates, is provided within paragraphs 3.1.30 to 3.1.35.

SuDS Departure 2: SuDS within the Functional Floodplain without Inundation Protection

3.1.9 Where drainage catchments have been constrained by flood extents and levels, the adoption of conventional SuDS components without inundation protection (i.e. SuDS constructed below existing ground levels) has been considered. This departure prevents the loss of floodplain storage and associated flood risk impacts. For drainage catchments D1, D2 and H, this departure allowed the adoption of conventional SuDS as a secondary level of treatment when undertaken in conjunction with SuDS Departure 1.

SuDS Departure 3: Adoption of Proprietary SuDS

3.1.10 ‘Proprietary SuDS’, in the form of geocellular attenuation tanks and hydrodynamic vortex separators (HVS), have been assessed as the only viable option to provide a second level of treatment on certain catchments constrained by flood extents and levels. This has typically been where SuDS without inundation protection has been discounted due to very flat topography and resulting hydraulic performance issues. It is noted ‘proprietary SuDS’ are not considered to provide an overall level of treatment equivalent to conventional SuDS, but are considered to provide a level of ‘proprietary SuDS treatment’. Further detail on these features is provided in paragraphs 3.1.24 to 3.1.26.

3.1.11 This approach has been adopted for drainage catchments B, F1, F2, G1 and G2, after exhausting the alternative options in line with Diagram 1. It is noted that geocellular attenuation tanks will require a widening of the mainline verge, and hence this approach has been undertaken in conjunction with SuDS Departure 1 to minimise the intrusion into the functional floodplain.

SuDS Departure 4: Discharging to Palaeochannels and Minor Watercourses

3.1.12 On drainage catchments F1, F2 and H, the options for discharging to watercourses have been constrained by both topography and flood levels. Discharging to groundwater only has been discounted due to the presence of raised groundwater levels in the study area and hence the risk of operational failure. Preliminary options proposed the construction of outfalls on the banks of the River Tay (WF6), however these required the construction of significant lengths of pipeline across the functional floodplain (with subsequent hydraulic performance issues); this would have also required construction within and hence disturbance to the River Tay SAC (with subsequent implications for the Habitats Regulations Assessment).

3.1.13 A solution to minimise the impacts on the River Tay SAC was to discharge to inundated ‘palaeochannels’ which are fed by minor watercourses draining from the adjacent hillside. Drainage catchments F1 and F2 are proposed to discharge to WF42, and drainage catchment H is proposed to discharge to WF55. Both WF42 and WF55 are historic channels associated with the River Tay (WF06) which are underlain by alluvial deposits. WF55 is a pond within a palaeochannel which is the result of a small impoundment. Both of these features drain towards the River Tay (WF06) via surface and subsurface mechanisms, which are dependent on inflows and groundwater levels, as inferred from hydrology, GI data, topography and flood modelling results.

JACOBS

3.1.14 During low or no flows within these water features, it is likely that any routine road runoff, that has not already infiltrated to groundwater during conveyance within filter drains, would infiltrate into a highly permeable unconfined aquifer (the alluvial deposits of the former channel). The hydraulic gradient and conductivity in these features would most likely result in a localised groundwater flow path along the route of the palaeochannel towards the River Tay (WF06). No groundwater abstractions or GWDTE have been identified down-gradient from the outfall locations which could be affected by the proposed discharges (refer to Chapter 10).

3.1.15 Therefore, discharging into these water features has been assessed as the preferred option for these drainage runs, due to:

- The requirement to minimise the construction and operational impacts on the River Tay SAC, and hence maximise biodiversity benefits, by removing direct drainage outfalls into the watercourse.
- The low sensitivity of the receiving palaeochannels (WF42 and WF55) and underlying localised superficial aquifers (refer to Appendix A11.1).
- The hydrology (inflow), topography and hydrogeology, indicating a degree of surface and shallow groundwater flow within these features towards the River Tay, with no stagnant water in which any residual pollutants could accumulate.
- Site surveys and existing drawings indicating that these water features are already receiving road runoff from the existing A9, which is generally untreated and un-attenuated (an exception being WF55 which receives runoff from the existing SuDS basins at Ballinluig). Therefore, a continuation or improvement on existing conditions is expected from the addition of SuDS associated with the proposed scheme.

3.1.16 Similarly, drainage runs D1, G1 and G2 will discharge into low sensitivity minor watercourses which infiltrate to groundwater during low flows (WF37 and WF50 respectively; refer to Appendix A11.1), and have been assessed as the preferred outfall locations for the same reasons as stated above.

Mainline SuDS

3.1.17 The SuDS management trains for the mainline carriageway of the proposed scheme, outfall locations (per drainage catchment) and a cross reference to the justification for their selection where departures are proposed, is provided within Table 1 below. Proposed discharge rates and attenuation standards are provided in Table 4.

Table 1: Proposed mainline SuDS

Drainage Catchment	NGR of Outfall Location		Receiving Water Feature	Water Feature Description	Proposed Management Train (MT)	Justification for Proposed SuDS Design
	Easting	Northing				
Run A1	300442	744134	River Tay	Major Watercourse	MT1: – Filter Drains – Wetland	Meets SuDS Design Principles
Run A2	300436	744684	River Tay	Major Watercourse	MT1: – Filter Drains – Wetland	Meets SuDS Design Principles
Run B	300318	745943	River Tay	Major Watercourse	MT3: – Filter Drains – HVS and Geocellular Tanks	Refer to SuDS Departures: 1 & 3
Run C	300090	747749	River Tay	Major Watercourse	MT4: – Filter Drains – Detention Basin	Meets SuDS Design Principles
Run D1	299894	748281	WF38	Minor Watercourse (Intermittent/ Ephemeral)	MT2: – Filter Drains – Swale	Refer to SuDS Departures: 1, 2 & 4
Run D2	299602	748747	River Tay	Major Watercourse	MT2: – Filter Drains	Refer to SuDS Departures: 1 & 2

Drainage Catchment	NGR of Outfall Location		Receiving Water Feature	Water Feature Description	Proposed Management Train (MT)	Justification for Proposed SuDS Design
	Easting	Northing				
					– Swale	
Run E	299501	749247	River Tay	Major Watercourse	MT1: – Filter Drains – Wetland	Refer to SuDS Departures: 1
Run F1	299259	750130	WF42	Palaeo-channel (Intermittent/ Ephemeral)	MT3: – Filter Drains – HVS and Geocellular Tanks	Refer to SuDS Departures: 1, 3 & 4
Run F2	299287	750305	WF42	Palaeo-channel (Ephemeral)	MT3: – Filter Drains – HVS and Geocellular Tanks	Refer to SuDS Departures: 1, 3 & 4
Run G1	298903	750920	WF50	Minor Watercourse (Ephemeral)	MT3: – Filter Drains – HVS and Geocellular Tanks	Refer to SuDS Departures: 1, 3 & 4
Run G2	298924	750951	WF50	Minor Watercourse (Ephemeral)	MT3: – Filter Drains – HVS and Geocellular Tanks	Refer to SuDS Departures: 1, 3 & 4
Run H	298095	751551	WF55	Palaeo-channel (Ephemeral)	MT1: – Filter Drains – Wetland	Refer to SuDS Departures: 1, 2 & 4

Side Road SuDS

3.1.18 The proposed side road drainage will incorporate a single level of SuDS treatment, which will generally comprise filter drains on either side of the carriageway, designed to allow for infiltration. There are some sections where conditions (topography and verge width within the earthworks) will also allow the adoption of swales instead of filter drains. The side roads will either outfall to minor watercourses that are crossed by the scheme or discharge into the mainline drainage. It is anticipated that the outfall structure, where discharging into a minor watercourse, can be embedded within the culvert design or can be located directly adjacent to the crossing structure.

3.1.19 It is noted that the Contractor will be permitted to develop, through detailed design, a side road SuDS arrangement that incorporates either filter drains or swales as a single level of treatment, subject to agreement with SEPA and Perth and Kinross Council.

Access Tracks

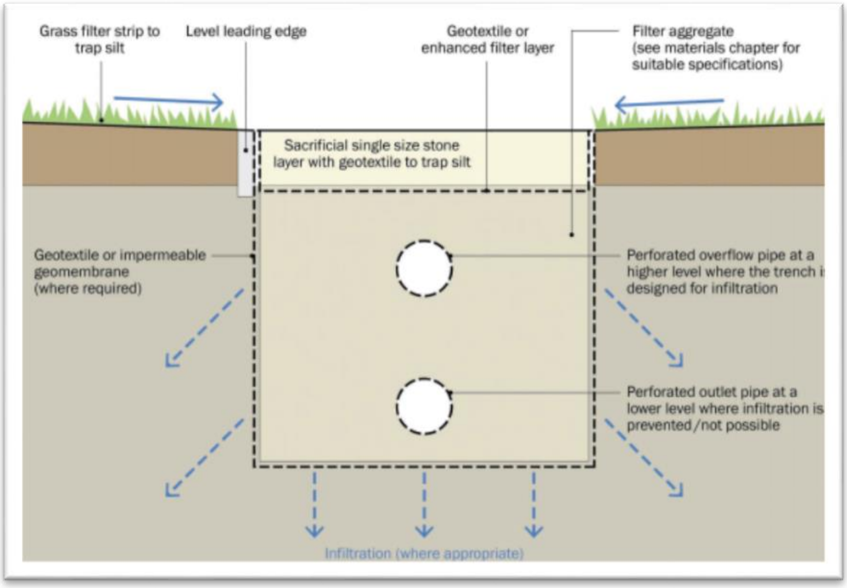
3.1.20 Access tracks are proposed to provide access to agricultural premises, residential properties and operational SuDS features. These tracks will generally be unsurfaced and feature vehicle movements lower than surfaced side roads. Drainage during operation will be provided through over-the-edge (OTE) drainage and/or soakaways.

Specific SuDS Components

Filter Drains

3.1.21 Filter drains are trenches alongside the carriageway filled with a permeable material or media designed to filter, temporarily detain and then convey runoff. At the base of the trench there is a perforated pipe, which conveys runoff downstream. The filter drains for the proposed scheme will be designed to allow infiltration, unless a requirement is identified by the contractor during detailed design to include an impermeable liner (e.g. groundwater levels or geotechnical constraints). Diagram 2 shows a typical schematic representation of a filter drain.

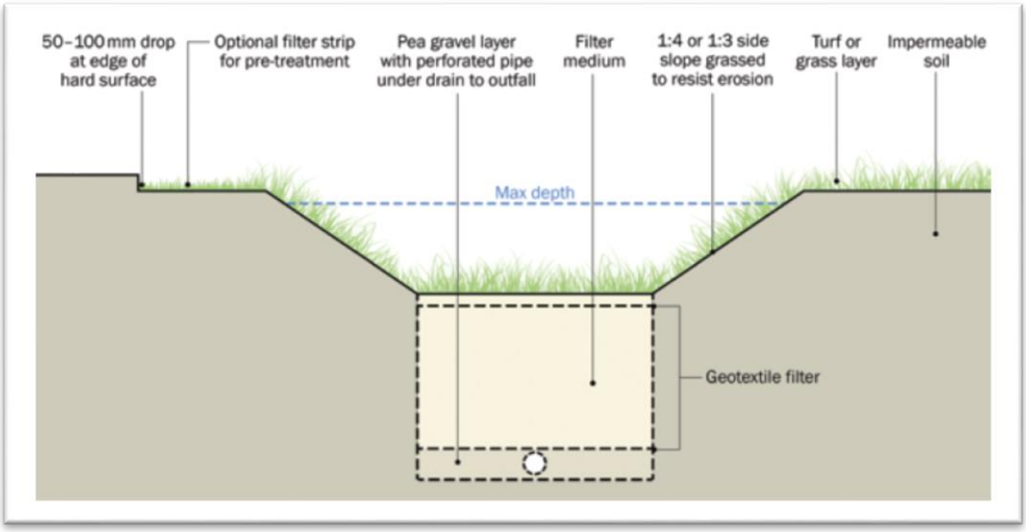
Diagram 2: Typical schematic of a filter drain from CIRIA (2015)



Swales

3.1.22 Swales are shallow, flat bottomed, vegetated channels designed to convey runoff and provide attenuation and treatment. Berms can be installed perpendicular to the flow path to allow runoff to temporarily pond, thus increasing pollutant retention and infiltration, as well as further reducing flow velocity. It is proposed that dry swales are adopted in order to allow infiltration into groundwater, which will provide enhanced treatment and attenuation. Diagram 3 shows a typical schematic representation of a dry swale.

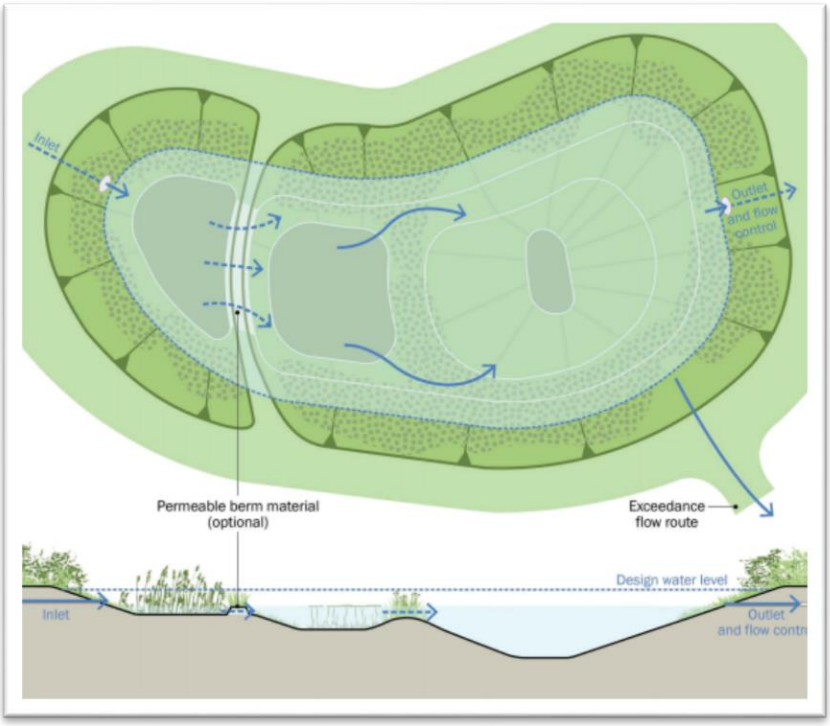
Diagram 3: Typical schematic of a dry swale from CIRIA (2015)



Wetlands

3.1.23 Wetlands are features that include a permanent volume of water (normally a maximum of 1.2m deep) and are designed to temporarily detain and treat runoff. They are largely similar to retention ponds, but a larger area is apportioned to aquatic plants, with shallow zones that promote the growth of bottom rooted plants, a more varied depth profile and optional inclusion of islands (CIRIA, 2015). This increased biological and morphological diversity can increase pollutant removal efficiency compared to retention ponds. Diagram 4 shows typical schematic representation of a wetland.

Diagram 4: Typical schematic of a wetland from CIRIA (2015)

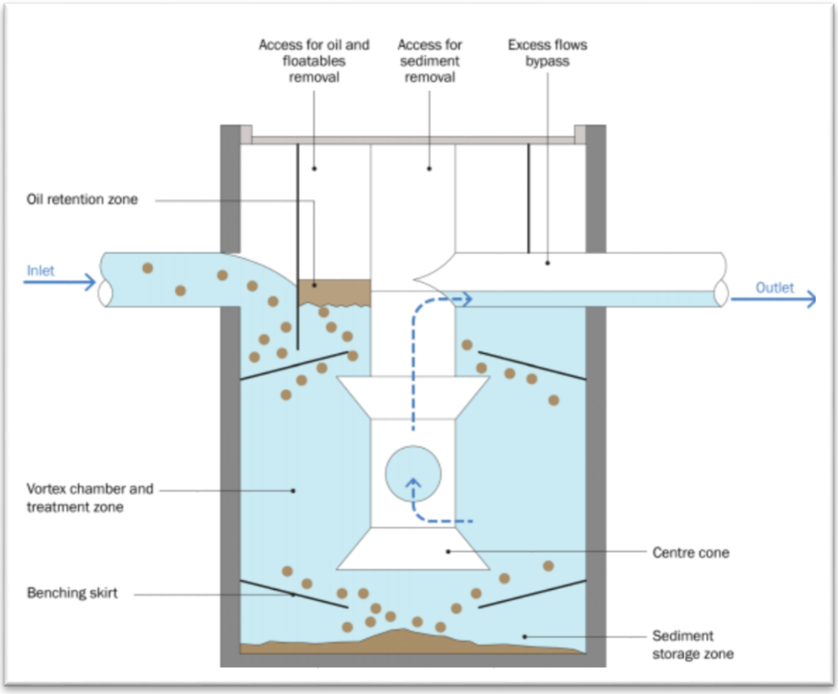


Hydrodynamic Vortex Separators (HVS)

3.1.24 Hydrodynamic Vortex Separators (HVS) are proprietary treatment devices designed as a source control measure to separate pollutants (predominantly sediment) through centrifugal force, allowing sediments to settle at the base and oils and floatables to rise to the top (access is provided for removal). Diagram 5 shows a typical schematic representation of a HVS.

3.1.25 It is noted that HVS do not provide any water quantity, amenity or biodiversity benefits and hence are the least preferred option in the SuDS selection process in Diagram 1.

Diagram 5: Typical schematic of a HVS from CIRIA (2015)

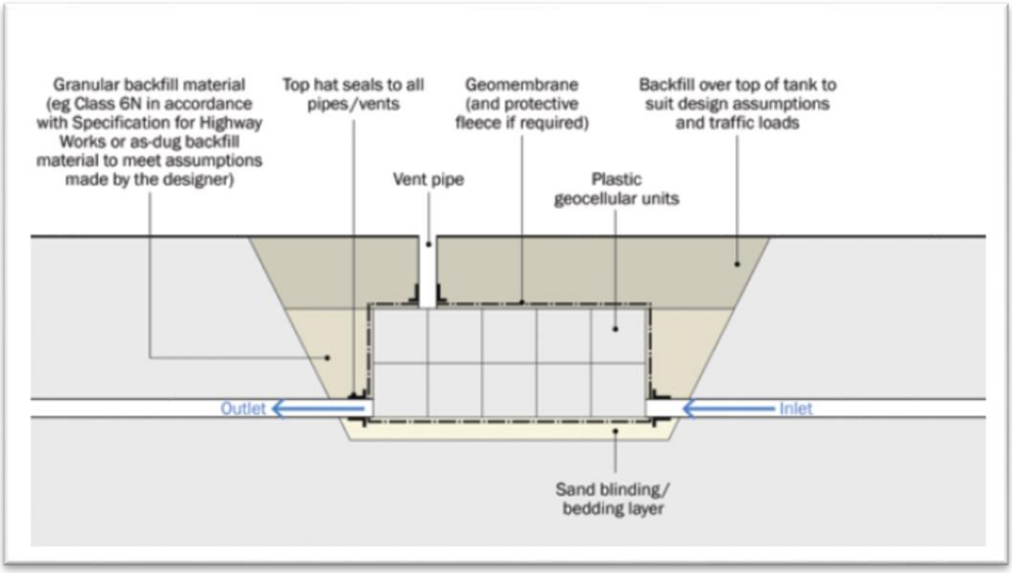


<u>Geocellular Attenuation Tanks</u>

3.1.26 Geocellular attenuation tanks are below-ground features composed of modular units which typically have 95% void space to provide temporary storage of surface water prior to controlled discharge (CIRIA, 2015). Multiple individual units can be assembled together in multiple layers if necessary to provide a bespoke sub-surface attenuation feature to meet site requirements. A typical schematic representation of a geocellular attenuation tank is shown in Diagram 6.

3.1.27 It is noted that geocellular attenuation tanks do not provide any water quality, amenity or biodiversity benefits and hence are the least preferred option in the SuDS selection process in Diagram 1.

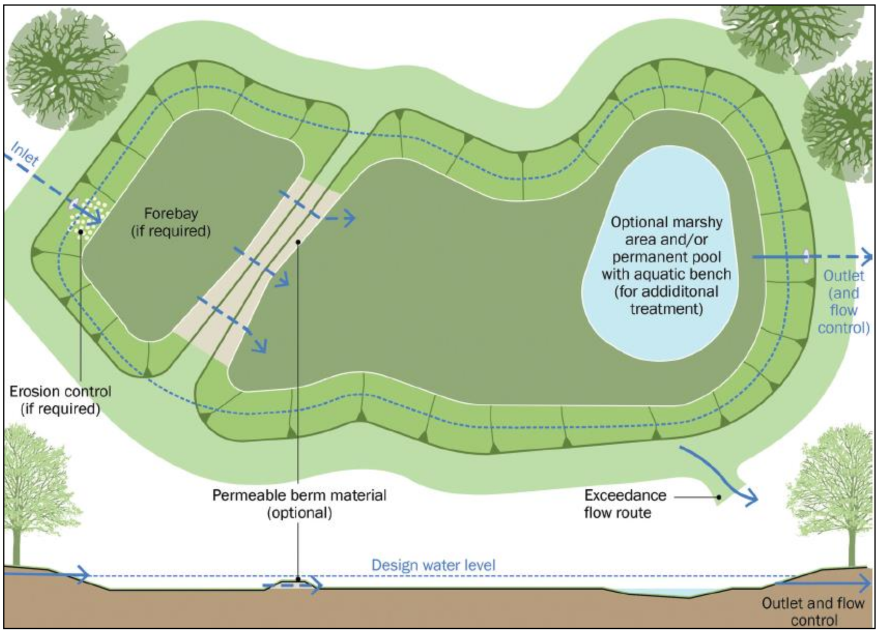
Diagram 6: Typical schematic of geocellular attenuation tank from CIRIA (2015)



Detention Basin

3.1.28 Detention basins are depressions that are normally dry and are designed to temporarily detain and treat runoff. They only contain a volume of water during and immediately after storm events and treatment occurs via settlement of suspended sediments and other pollutants; filtration through vegetation on the basin base; biodegradation; and volatilisation (conversion of pollutants to a gas). Diagram 7 shows a typical schematic representation of a detention basin.

Diagram 7: Typical schematic of a detention basin (from CIRIA, 2015)



Indicative SuDS Maintenance

3.1.29 An indicative SuDS maintenance regime, as taken from the SuDS Manual (CIRIA, 2015) for each proposed SuDS component, is detailed in Table 2 below.

Table 2: Indicative SuDS maintenance schedule

Maintenance Schedule	Required Action	Typical / Recommended Frequency
Hydrodynamic Vortex Separators (HVS)		
Routine maintenance	Remove litter and debris and inspect for sediment oil and grease accumulation	Every 6 months
	Change the filter media	At least once a year but site-specific depending on hydrological loading
	Remove sediment, oil, greases and floatables	Once annually OR indicated by system inspections or immediately following significant spill
Remedial actions	Replace malfunctioning parts or structures	As required
Monitoring	Inspect for evidence of poor operation	Every 6 months
	Inspect filter media and establish appropriate replacement frequencies	Every 6 months
	Inspect sediment accumulation rates and establish appropriate removal frequencies	Monthly during the first 6 months then every 6 months thereafter
Geocellular Attenuation Tanks		
Routine maintenance	Remove debris from catchment surface in locations where it risks system performance	Monthly
	Inspect and identify areas not operating correctly	Monthly for 3 months then once annually

Maintenance Schedule	Required Action	Typical / Recommended Frequency
	Remove sediment from pre-treatment structures and/internal forebays	Annually OR as required
Remedial actions	Repair or replace inlets, outlet, overflows and vents	As required
Monitoring	Inspect all inlets, outlets, vents and overflows to ensure they are in good condition and operating as designed	Annually
	Survey inside tank for sediment accumulations and remove as necessary	Every 5 years OR as required
Filter Drains		
Regular maintenance	Remove litter and debris from drain surface, access chambers and pre-treatment devices	Monthly OR as required
	Inspect filter drain surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage	Monthly
	Inspect pre-treatment systems, inlets and perforated pipework for silt accumulation	Every 6 months
	Remove sediment from pre-treatment devices	Every 6 months OR as required
Occasional maintenance	In high pollution load areas, remove and replace surface geotextile and wash or replace overlying filter media	Every 5 years OR as required
	Clear perforated pipework of blockages	As required
Wetlands and Detention Basin		
Regular maintenance	Remove litter and debris	Monthly OR as required
	Inspect marginal and bankside vegetation and remove nuisance plants	Monthly at start then as required, Nuisance plants should be removed for first 3 years
	Inspect feature including inlet, outlet and pipework for evidence of blockage or physical damage	Monthly
	Inspect waterbody for signs of poor water quality	Monthly (May – October)
	Inspect silt accumulation rates and establish removal frequencies	Every 6 months
	Check any mechanical devices	Every 6 months
	Management of submerged, emergent and bank vegetation	Annually
	Remove sediment from any forebay	Every 1-5 years OR as required
	Remove sediment and planting from one quadrat of the main body of ponds without sediment forebays	Every 5 years OR as required
Occasional maintenance	Remove sediment from main body of big ponds when pool volume is reduced by 20%	Approximately every 25 - 50 years' subject to pre-treatment effectiveness
Remedial actions	Repair erosion or other damage, replant where necessary	As required
	Aerate pond if signs of eutrophication are present	As required
	Realign rip-rap or repair other damage	As required
Swales		
Regular Maintenance	Remove litter and debris	Monthly OR as required
	Cut grass to retain height in line with specified design range	Monthly during growing season OR as required
	Manage other vegetation and remove nuisance plants	Monthly (at start) then as required
	Inspect inlets, outlets and overflows for blockages and clear as necessary	Monthly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation and record areas where ponding for >48 hours	Monthly OR as required
	Inspect inlets and surface for silt accumulation and establish appropriate silt removal frequency	Every 6 months

Maintenance Schedule	Required Action	Typical / Recommended Frequency
Occasional maintenance	Reseed areas with poor vegetation growth and alter plant composition to better suit conditions if needed	As required if exposed bare soil is >10% of swale treatment area
Remedial actions	Repair erosion or other damage by re-turfing or reseeding	As required
	Re-level uneven surfaces and reinstate design levels	As required
	Remove build-up of sediment on upstream gravel trench, flow separator or at top of filter strip	As required
	Remove oils or petrol residues	As required

Attenuation and Restricted Discharge Rates

3.1.30 The drainage strategy for surface water (quantity) is to ensure that the post development flows within receiving watercourses do not increase with respect to the pre-development conditions for all return period events.

3.1.31 On the A9 Dualling Programme, this has generally been achieved by attenuating the greenfield surface runoff generated from the overall development footprint from all storms, up to the 0.5% AEP (200-year) plus CC event, with controlled outflow at the greenfield discharge rate of QMED (50% AEP (2-year) event). This represents an improvement from existing discharge rates as existing impermeable areas (i.e. the existing A9) are not considered.

3.1.32 As discussed in paragraphs 3.1.7 to 3.1.8 (SuDS Departure 1), a reduced standard of attenuation has been considered where the adoption of SuDS, sized to the above standard, has been significantly constrained by flood levels, flood extent, topography and subsequent hydraulic performance issues. In such cases, efforts have been made to size the attenuation systems to a reduced rainfall event of 3.33% AEP (30-year) plus CC, with discharge rates restricted to pre-development QMED runoff rates, taking into consideration the existing impermeable area within each drainage catchment (refer to paragraphs 2.1.4 and 2.1.5).

3.1.33 Drainage design software (Micro Drainage) has been used to estimate the required size for SuDS attenuation components (wetlands, swales and geocellular tanks). The models have simulated the required rainfall event based on the contributing permeable and impermeable surface areas and subsequent flow mechanisms within the pipe network. Where achievable, a freeboard of 300mm has been adopted for the SuDS attenuation components. Surcharged flows have been designed to spill over an overflow weir above the designed top water level, and overland conveyance routes have been assessed to ensure flows are routed to the nearest watercourse to avoid any downstream flood risk receptors (refer to Appendix A11.3).

3.1.34 Greenfield and existing runoff rates have been estimated using the methods outlined in the guidance document ‘Preliminary Rainfall Runoff Management for Developments’ (Environment Agency, 2012). Table 3 and Table 4 below provide the:

- Existing and proposed permeable and impermeable surface areas within each drainage catchment;
- Greenfield runoff rates (QMED) for each drainage catchment (excluding any existing impermeable areas);
- Existing runoff rates (QMED) from each drainage catchment accounting for the existing impermeable areas), for where SuDS Departure 1 has been adopted; and
- Proposed restricted discharge rates and standards; and
- Proposed attenuation volumes and the subsequent rainfall return period attenuated.

Table 3: Pre-development runoff rates

Drainage Catchment	Receiving Watercourse	Total Development Area (Ha)	Existing Impermeable Area (Ha)	Greenfield Runoff Rates (QMED) (l/s)	Existing Runoff Rate (QMED) (l/s)
A1	River Tay	4.65	0.73	26.0	31.8
A2	River Tay	2.16	0.41	10.3	13.2
B	River Tay	8.00	1.81	38.1	50.9
C	River Tay	3.84	0.72	16.2	20.6
D1	WF38	1.88	0.70	5.2	8.3
D2	River Tay	4.31	0.64	15.5	18.8
E	River Tay	1.77	0.77	7.1	12.1
F1	WF42	1.68	0.61	6.0	9.3
F2	WF42	1.01	0.22	2.9	3.8
G1	WF50	3.86	0.38	10.6	12.0
G2	WF50	1.45	0.47	4.0	6.0
H	WF55	1.68	0.66	4.1	6.6

Table 4: Post-development discharge rates and attenuation

Drainage Catchment	Receiving Watercourse	Proposed Impermeable Area (Ha)	Proposed Permeable Area (Ha)	Proposed Discharge Rate (l/s)	Proposed Attenuation Volume (m^3)	Rainfall Return Period Event Attenuated
A1	River Tay	2.214	2.434	26.0 (Greenfield QMED)	2282	0.5% AEP (200-year) plus CC
A2	River Tay	0.962	1.194	10.3 (Greenfield QMED)	941	0.5% AEP (200-year) plus CC
B	River Tay	4.286	3.718	50.9 (Existing QMED)	1624	3.33% AEP (30-year) plus CC
C	River Tay	2.293	1.548	16.2 (Greenfield QMED)	2479	0.5% AEP (200-year) plus CC
D1	WF38	1.560	0.319	8.3 (Existing QMED)	786	3.33% AEP (30-year) plus CC
D2	River Tay	2.207	2.098	18.8 (Existing QMED)	1085	3.33% AEP (30-year) plus CC
E	River Tay	1.562	0.203	12.1 (Existing QMED)	594	3.33% AEP (30-year) plus CC
F1	WF42	1.356	0.32	9.3 (Existing QMED)	589	3.33% AEP (30-year) plus CC
F2	WF42	0.744	0.268	3.8 (Existing QMED)	409	3.33% AEP (30-year) plus CC
G1	WF50	1.064	2.793	12.0 (Existing QMED)	715	3.33% AEP (30-year) plus CC
G2	WF50	1.119	0.333	6.0 (Existing QMED)	586	3.33% AEP (30-year) plus CC
H	WF55	1.155	0.529	6.6 (Existing QMED)	1301	3.33% AEP (30-year) plus CC

3.1.35 When considering the cumulative impacts on the River Tay catchment as a result SuDS Departure 1, it is noted that the order of magnitude difference between (i) the river flow rates (e.g. 50% AEP (2-year) = 356m^3/s upstream of study area; refer to Appendix A11.2), and (ii) combined maximum drainage discharge rates (= 0.180m^3/s), is significant. Therefore, the River Tay and associated downstream flood receptors are not considered to be sensitive to the reduced attenuation standard, and they would likely be more sensitive to any loss of floodplain storage through not reducing the size of these SuDS components.

3.1.36 The methodology for the greenfield runoff rate estimation is further discussed in Appendix A11.2 (Surface Water Hydrology), and the overall assessment of flood risk associated with the proposed scheme is provided within Appendix A11.3 (Flood Risk Assessment).

4 Water Quality Assessment

Methodology

4.1.1 Water quality assessments for the proposed mainline have been undertaken in accordance with DMRB HD45/09 (Highways Agency et al., 2009) using the Highways England (formally Highways Agency) Water Risk Assessment Tool (HAWRAT). The assessments undertaken include Method A, which assesses the impacts on receiving watercourses from routine runoff, and Method D, which assess the risk from the accidental spillage of pollutants.

4.1.2 In addition, an assessment of the impact from de-icing activities, and specifically chloride (Cl^-), has been undertaken using a simple mass balance approach. The suitability of the proposed side road SuDS has also been assessed using the Simple Index Approach (SIA), in-line with SEPA's Regulatory Guidance (WAT-RM-08) Sustainable Urban Drainage Systems (SUDS or SuD Systems) (SEPA, 2017) and as detailed within CIRIA (2015).

<u>HAWRAT Method A: Routine Runoff Assessment</u>

4.1.3 The HAWRAT assessment uses statistically based models for predicting the quality of road runoff in terms of specific soluble and sediment-bound pollutants. The models use traffic density, climatic region and event rainfall characteristics to predict runoff quality in terms of Event Mean Concentrations (EMCs) and Event Mean Sediment Concentrations (EMSCs).

4.1.4 The tool then predicts the impact of the road runoff on receiving watercourses. For soluble pollutants, the assessment comprises a simple mass balance calculation accounting for river flows and hence dilution of pollutants. For sediment bound pollutants, the model considers both the likelihood and extent of sediment accumulation.

4.1.5 Dissolved copper (Cu) and dissolved zinc (Zn) are used as indicators of the level of impact from soluble pollutants, as they are known to result in acute toxic effects to aquatic ecology at certain threshold concentrations. The assessment results detail whether the SuDS discharge would 'pass' or 'fail' in terms of the frequency that pollutant thresholds are exceeded. For sensitive sites such as those within the study area, the toxicity thresholds may only be exceeded once per year in any given 24-hour period or 0.5 times per year in any given 6-hour period.

4.1.6 HAWRAT also estimates in-river annual average concentrations for dissolved Cu and dissolved Zn that can be compared to adopted Environmental Quality Standards (EQS) as detailed in The Scotland River Basin District (Standards) Directions 2014, which are 1µg/l and 10.9µg/l for dissolved copper (bioavailable) and dissolved zinc (bioavailable) respectively.

4.1.7 Chronic impacts associated with sediment-bound pollutants are also identified by assessing concentrations of total copper, zinc, cadmium, pyrene, fluoranthene, anthracene, phenanthrene and total PAH (Polycyclic Aromatic Hydrocarbons). These concentrations are similarly assessed against ecological-based thresholds to determine the toxicity risk. A 'pass' or 'fail' result is also given, however an 'alert' is given for outfalls that would otherwise pass the assessment for sediment-bound pollutants, were it not for the following features being present downstream:

- a protected site within 1km of the point of discharge; and
- a structure, lake or pond within 100m of the point of discharge.

4.1.8 The efficiency of the proposed SuDS components in treating pollutants (treatment efficiencies) has been obtained using data provided in Table 26.13 of the SuDS Manual (CIRIA, 2015) and Table 8.1 of DMRB HD33/16 (Highways England et al., 2016). Further details of the treatment efficiencies used in the assessments are provided in Annex 1 (Water Quality Assessment Input Data).

4.1.9 The HAWRAT routine runoff assessment uses a three-step approach to assess the impacts of both soluble and sediment-bound pollutants. The three-step approach is as follows:

- Step 1: estimates pollutant concentrations in the undiluted road runoff;
- Step 2: estimates pollutant concentrations after dilution within the receiving watercourse; and
- Step 3: estimates pollutant concentrations after mitigation (i.e. the treatment provided by the proposed SuDS) and dilution within the receiving watercourse.

4.1.10 Only Step 2 and Step 3 results are presented within this appendix. These results subsequently translate into the pre-mitigation (Step 2) and post-mitigation or residual (Step 3) impact magnitudes, as presented within Appendix A11.7 (Impact Assessment) and Chapter 11 (Road Drainage and Water Environment).

4.1.11 The input data and associated sources used within the routine runoff assessments are presented in Table 5. Annex 1 of this document provides the full list of input data specific to each drainage catchment.

Table 5: Method A standard input data and data sources

Parameter	Value Used	Notes / Data Sources
Annual Average Daily Traffic (AADT)	>10,000 and <50,000	Design year 2041 Source: Jacobs' traffic modelling team.
Climatic Region	Colder Wet	Source: HAWRAT Help v1.0
Rainfall Site	Ardtalnaig (SAAR 1343.9mm)	Source: HAWRAT Help v1.0
Hardness	Low = <50mg $CaCO_3$/l	Worst-case scenario. SEPA water quality monitoring data for River Tay at Pitnacree used as donor information.
95%ile River Flow (m^3/s)	Specific to each outfall location	Source: Jacobs' hydrologists
Baseflow Index (BFI)	Specific to each outfall location	Source: FEH CD - ROM
Impermeable and permeable area draining to outfall (ha)	Specific to each drainage catchment	Source: scheme information
Receiving watercourse dimensions (estimated river width at Q95, bed width, side slope and long slope)	Specific to each outfall location	Source: site information
Receiving watercourse Manning's n	Specific to each outfall location	Source: site information and with reference to Chow (1959)
Existing treatment of solubles and sediment (%)	0	Only partial treatment on the existing A9. Precautionary approach to assume no existing treatment.
Proposed treatment of solubles and sediments (%)	Specific to each drainage catchment	Sources: SuDS Manual (C753) Table 26.13 – Performance of SuDS components in reducing urban runoff contamination and DMRB HD 33/16 (2016) Table 8.1 – Indicative Treatment Efficiencies of Drainage Systems
Proposed attenuation – restricted discharge rate (l/s) to Q_{BAR}	Specific to each drainage catchment	Source: Jacobs' engineers

<u>HAWRAT Method D: Spillage Risk Assessment</u>

4.1.12 Method D of DMRB HD45/09 has been designed to calculate spillage risk during the operation of the proposed scheme and the associated probability of a serious pollution incident. The risk is calculated assuming that an accident involving spillage of pollutants onto the carriageway would occur at an assumed frequency (expressed as annual probabilities) based on calculated traffic volumes; the percentage of that traffic volume that is considered a Heavy Goods Vehicle (HGV); and the type of road/junction within each drainage catchment.

4.1.13 The probability that a spillage will cause a pollution incident is calculated as:

$P_{INC} = P_{SPL} \times P_{POL}$; *where:*

- P_{SPL} = probability of a serious accidental spillage in one year over a given road length, which is calculated using the road length, risk factors associated with the specific road type, and AADT and % Heavy Good Vehicles in the design year (2041 for the proposed scheme); and
- P_{POL} = the risk reduction factor, dependent upon emergency services response times, which determines the probability of a serious spillage leading to a serious pollution incident of surface waters (factor of 0.6 is applied for the proposed scheme as it is a rural trunk road with a response time of >20minutes and <1 hour).

4.1.14 In line with DMRB HD45/09 (Highways Agency et al., 2009a), where spillage risk is calculated as less than the 0.5% AEP (200-year), the spillage risk falls within acceptable limits even when road runoff discharges within close proximity (i.e. within 1km) to a designated conservation sites (i.e. the River Tay SAC).

Impacts from De-icing Activities

4.1.15 In the absence of an existing method, a simple and conservative risk-based model has been developed to assess the impacts of de-icing activities, and specifically salt spreading and associated Cl^- concentrations, within road runoff and receiving watercourses.

4.1.16 The method uses UK Roads Liaison Group, (2013) guidance on the maximum application rate of road salt, combined with information of the ratio of road salt to brine in pre-wetted salt application; to estimate the mass (kg) of salt applied per square meter of road and subsequently per section of road draining to each outfall.

4.1.17 The second stage of the assessment considers the dilution available within the receiving watercourse, which because of the winter conditions at the time of application, is calculated from the estimated mean flow in each watercourse. No allowance for background salt concentrations is currently included in the assessment.

4.1.18 In the absence of a UK short-term EQS for Cl^-, the subsequent concentration of Cl^- in the receiving watercourse is therefore assessed against a guidance concentration threshold of 640mg/l as reported by the Canadian Council of Ministers to the Environment (2011) for short-term exposure. The Canadian guidance is based on Cl^- toxicity tests which included a mussel species with similar biology and ecology to the freshwater pearl mussel native to the UK. Freshwater mussels are noted in the Canadian guidance document as being the most sensitive taxonomic group to Cl^-.

4.1.19 The standard input parameters used within the Cl^- assessments are provided in Table 6 below.

Table 6: Standard input parameters to assessment of Cl-

Parameter	Value Used	Source
Max application of salt per m^2	$40g/m^2$	UK Roads Liaison Group (2013)
Rainfall depth	5mm	Value adopted relates to the first flush rainfall depths used in the 'The SuDS Manual' (CIRIA, 2015).
Ratio of dry salt to brine	70:30	UK Roads Liaison Group (2013).
Runoff Coefficient	1	Coefficient as used in the HAWRAT.
Canadian Water Quality Guideline for Short-term exposure (WQG-S) to Chloride	$640mgCl^-/l$	Canadian Council of Ministers to the Environment (2011)

4.1.20 It is noted the results of the Cl^- assessment have not been included within the overall impact assessment for the proposed scheme due to the lack of a UK short-term EQS for Cl^-, published data on SuDS treatment efficiencies in removing Cl^-; and a defined methodology for assessing the impacts of Cl^- in line with the DMRB.

Simple Index Approach for Side Roads

4.1.21 The Simple Index Approach has been used to determine the suitability of the SuDS proposed for side road drainage in-line with SEPA's Regulatory Guidance (WAT-RM-08) Sustainable Urban Drainage Systems (SUDS or SUD Systems) (SEPA, 2017). The Simple Index Approach, as detailed within 'The SuDS Manual' (CIRIA, 2015), was developed from a study by Ellis et al. (2012) and comprises two key components:

- Pollution Hazard Indices (PHI) of between 0 and 1, based on the pollutant levels likely for different land-use types, where higher values indicate higher pollutant levels; and
- Pollution Mitigation Indices (PMI) of between 0 and 1, based on the ability of SuDS components or groundwater protection measures to treat pollutants, where higher values indicate higher treatment efficiency.

4.1.22 PHI and PMI values are given for three broad pollutant categories: Total suspended solids (TSS), Metals, and Hydrocarbons. Where PHI is assessed to be less than PMI, mitigation or proposed SuDS is considered sufficient to treat runoff from the pollution source.

4.1.23 It is noted that side roads are generally surfaced, minor roads that will experience traffic flows (AADT) in the region of 60 to 350 vehicles per day (VPD). Traffic volumes for 'low traffic roads' are defined as <300 traffic movements per day (CIRIA, 2015); therefore, this category is deemed to be the most representative for the proposed side roads.

Limitations

4.1.24 The following key limitations to the water quality assessments undertaken are noted:

- The routine runoff (Method A) assessment is noted as having a limited ability for assessing impacts on watercourses which are intermittent or ephemeral, with guidance within DMRB HD45/09 stating that the impacts on groundwater should be considered in such instances.
- The basic data that has informed the HAWRAT tool is derived from several English motorways, which is noted as causing some notable differences when applied in Scotland. For example, on the A9 Dualling projects, the accidental spillage risk assessment results have been observed to be far below the acceptable limits even without mitigation, which is presumed to be due to the comparatively low traffic and HGV volumes.
- The rainfall data used within the tool is taken from the nearest rainfall station (Ardtalnaig) for which such data is available. This station is approximately 30km west from the proposed scheme, therefore there may be some differences in the rainfall events that occur within the study area.
- The quoted SuDS treatment efficiencies taken from CIRIA (2015) and Highways England et al. (2016) are derived from limited studies, and do not account for the length or size of certain SuDS components. In addition, there is no published data on the treatment of Cl- from SuDS, limiting the assessment of impacts from de-icing activities.
- Existing water quality within receiving watercourses is not directly taken into consideration in the HAWRAT routine runoff model; however, it is taken into consideration when assigning sensitivity (Appendix A11.1) and thus determining the impact significance (Appendix A11.7 and Chapter 11).
- Due to the lack of detailed GI, an assessment of the impacts to groundwater quality, in line with DMRB HD45/09 Method C, has not been undertaken, although filter drains will be designed to infiltrate as standard and discharging to intermittent/ephemeral water features is proposed. Detailed GI data will be available at the time of CAR licensing which will enable the undertaking of further assessments as required by SEPA.

Results

4.1.25 The results from the HAWRAT Method A and D, and assessment of impacts from de-icing activities, are provided in Table 7. The results of cumulative assessments using HAWRAT Method A and D are provided in Table 8.

HAWRAT Method A: Routine Runoff Assessment

4.1.26 After the adoption of mitigation (Step 2), outfalls D1 (discharging to WF38), F1 and F2 (both discharging to WF42) and G1 and G2 (both discharging to WF50) continue to ‘Fail’ components of the HAWRAT routine runoff assessment. For drainage runs D1, F1 and F2, ‘Fail’ results are reported for only soluble pollutant impacts (a Zn fail for D1 and a Cu Fails for F1 and F2 respectively), which translates into a ‘Minor adverse’ magnitude of impact for the receiving water features (WF37 and WF42). The ‘Fail’ results for outfalls G1 and G2 are reported for soluble pollutant impacts (both Cu and Zn) and exceedance of the EQS for dissolved Cu, which translates into a ‘Major adverse’ impact on WF50.

4.1.27 The cumulative assessments for both drainage Runs F (F1 and F2) and G (G1 and G2) result in a failure for soluble pollutant impacts and exceedance of the EQS for dissolved Cu, which translates into a ‘major adverse’ impact on WF42 and WF50 respectively.

4.1.28 All drainage Runs have an ‘Alert’ for sediment bound pollutants associated with them during Step 2 (Pre-mitigation) and Step 3 (Post-mitigation). The one exception is a ‘Fail’ result on sediment bound pollutants at Step 2 for Run F1.

4.1.29 The failures of the HAWRAT routine runoff assessments, after the adoption of mitigation, are associated with minor watercourses and ephemeral water features with very low Q_{95} flows (0.0006 – 0.0022m^3/s). It is acknowledged within DMRB HD45/09 that the HAWRAT tool has limited ability in assessing impacts on ephemeral watercourses, as increasing the mitigation will still not enable a ‘Pass’ result if Q_{95} flows are sufficiently low not to allow dilution. As discussed in SuDS Departure 4 (paragraphs 3.1.13 and 3.1.16), discharging to these palaeochannels and minor watercourses has been assessed as the preferred option, regardless of the HAWRAT results, when considering the local hydrogeology and the desire to minimise impacts on the River Tay SAC.

4.1.30 In addition, once the sensitivity of the watercourses has been taken into consideration, no watercourse is reported as having a significant impact (‘Moderate adverse’ or above) within Chapter 11 (Road Drainage and Water Environment). Therefore, a ‘Fail’ of the HAWRAT routine runoff assessments does not prerequisite a redesign or adoption of further mitigation in this instance.

HAWRAT Method D: Spillage Risk Assessment

4.1.31 The annual probability of a serious pollution incident occurring within each highway catchment draining to an individual outfall has been estimated to be far below the 0.5% AEP (200-year) guidance quoted in DMRB HD45/09 for sensitive areas (Table 7). Likewise, the summed annual probability of a serious pollution incident occurring across the cumulative drainage catchments is observed to be below the 0.5% AEP (200-year) threshold (Table 8).

4.1.32 Although the risk of a spillage event has been assessed as low, spillage control valves will form part of the SuDS outlet designs for attenuation features (swales, wetlands, geocellular storage tanks and detention basins) to contain any pollutants in the event of a spillage.

Impacts from De-icing Activities

4.1.33 The results of the salt assessment show that concentrations of Cl^- exceed the Canadian short-term water quality guideline value of 640mg/l at four water features (WF38, WF42, WF50 and WF55). These water features are of a low sensitivity, as they are generally unsuitable for fish species (presently and are likely to continue to be unsuitable in the future) and no protected aquatic ecological species have been identified within them. In addition, removal of Cl^- from SuDS has not been assessed as there are currently no published values available that represent a SuDS treatment efficiency of Cl^-. Salt loading from the existing A9 is a further consideration that has not been included within the assessment.

4.1.34 Concentrations of Cl^- within WF38, WF42, WF50 and WF55 will become further diluted when they discharge into the River Tay SAC, which is the nearest location where protected species could be impacted by Cl^-. The assessment shows that the significant dilution which would occur, would reduce Cl^- levels to below the Canadian short-term guideline value.

Table 7: Mainline water quality assessment results

Drainage Catchment	Receiving Watercourse	HAWRAT Routine Runoff Assessment (Method A)					HAWRAT Spillage Risk Assessment (Method D)		Assessment of De-icing Activities	
		Dissolved Cu	Dissolved Zn	Cu EQS Compliance (µg/l)	Zn EQS Compliance (µg/l)	Sediment Bound Pollutants	Return Period (years)	Within Acceptable Limits?	Concentration Cl- (mg/l)	Comparison with Canadian Reg. Standard
Pre- Mitigation (Step 2)										
Run A1	River Tay	Pass	Pass	Pass (0.00)	Pass (0.00)	Alert	2098	Yes	61	Pass
Run A2	River Tay	Pass	Pass	Pass (0.00)	Pass (0.00)	Alert	8222	Yes	61	Pass
Run B	River Tay	Pass	Pass	Pass (0.00)	Pass (0.00)	Alert	2039	Yes	62	Pass
Run C	River Tay	Pass	Pass	Pass (0.00)	Pass (0.00)	Alert	3726	Yes	61	Pass
Run D1	WF38	Fail	Fails	Fail (1.63)	Pass (5.05)	Alert	10469	Yes	1365	Fail
Run D2	River Tay	Pass	Pass	Pass (0.00)	Pass (0.00)	Alert	5973	Yes	61	Pass
Run E	River Tay	Pass	Pass	Pass (0.00)	Pass (0.00)	Alert	6252	Yes	61	Pass
Run F1	WF42	Fail	Fail	Pass (0.83)	Pass (2.56)	Fail	13380	Yes	983	Fail
Run F2	WF42	Fail	Fail	Pass (0.68)	Pass (2.08)	Alert	20798	Yes	692	Fail
Run G1	WF50	Fail	Fail	Fail (1.50)	Pass (4.68)	Alert	9494	Yes	1684	Fail
Run G2	WF50	Fail	Fail	Fail (1.69)	Pass (5.26)	Alert	7920	Yes	1408	Fail
Run H	WF55	Fail	Fail	Fail (1.06)	Pass (3.28)	Alert	5515	Yes	1074	Fail
Post-Mitigation (Step 3)										
Run A1 / A2 / B / C / D2 / E	River Tay	Pass	Pass	Pass (0.00)	Pass (0.00)	Alert	Pre-mitigation results are within acceptable limits, therefore post-mitigation results have not been assessed.		Post-mitigation concentrations not known. No data available on SuDS treatment of Cl-.	
Run D1	WF38	Pass	Fail	Pass (0.82)	Pass (2.56)	Alert				
Run F1	WF42	Fail	Pass	Pass (0.83)	Pass (1.32)	Alert				
Run F2	WF42	Fail	Pass	Pass (0.68)	Pass (1.08)	Alert				
Run G1	WF50	Fail	Fail	Fail (1.50)	Pass (2.39)	Alert				
Run G2	WF50	Fail	Fail	Fail (1.69)	Pass (2.71)	Alert				
Run H	WF55	Pass	Pass	Pass (0.75)	Pass (1.40)	Alert				

Table 8: Cumulative mainline water quality assessment results

Drainage Catchment	Receiving Watercourse	HAWRAT Routine Runoff Cumulative Assessment (Method A)					HAWRAT Spillage Risk Assessment (Method D)	
		Dissolved Cu	Dissolved Zn	EQS Compliance (Cu)	EQS Compliance (Zn)	Sediment Bound Pollutants	Return Period	Within Acceptable Limits?
Pre- Mitigation (Step 2)								
F1+ F2	WF42	Fail	Fail	Fail	Pass	N/A as all outfalls greater than 100m apart		
A1+A2	River Tay	Pass	Pass	Pass	Pass			
G1+G2	WF50	Fail	Fail	Fail	Pass	Alert		
All outfalls	River Tay						432	Yes
Post-Mitigation (Step 3)								
F1+F2	WF42	Fail	Fail	Fail	Pass	N/A as all outfalls greater than 100m apart	Pre-mitigation results are within acceptable limits, therefore post-mitigation results have not been assessed.	
A1+A2	River Tay	Pass	Pass	Pass	Pass			
G1+G2	WF50	Fail	Fail	Fail	Pass	Alert		

Simple Index Approach for Side Roads

4.1.35 The results from the Simple Index Approach for side road drainage are presented in Table 9 below. The results indicate that swales would be the preferred level of treatment for side road drainage, with additional Total Suspended Solids (TSS) mitigation recommended when only filter drains / infiltration trenches are proposed.

4.1.36 However, the Simple Index Approach does not consider the length of filter drains, and for the proposed scheme, filter drains will be constructed on both sides of the side road thereby enhancing their length and treatment relative to the impermeable area. Therefore, this is considered likely to provide sufficient enhancement to the treatment of TSS where swales cannot be accommodated.

Table 9: Side road water quality assessment results

Parameter	Category	TSS	Metals	Hydrocarbons
PHI	Low traffic roads (e.g. residential roads and general access roads, < 300 traffic movements/day)	0.5	0.4	0.4
Option 1: Filter drain (designed to allow for infiltration)				
PMI Groundwater Protection	Infiltration trench with suitable depth of filtration material underlain by 300mm minimum depth of soils with good contamination attenuation potential	0.4	0.4	0.4
Sufficiency of Pollutant Mitigation Indices (PHI≤PMI)		Additional TSS Mitigation Required	Sufficient	Sufficient
Option 2: Swale				
PMI SuDS	Swale	0.5	0.6	0.6
Sufficiency of Pollutant Mitigation Indices (PHI≤PMI)		Sufficient	Sufficient	Sufficient

JACOBS

5 Summary

5.1.1 In summary, the development of a SuDS design in line with the agreed A9 SuDS design principles has been significantly constrained by fluvial flood levels and extents, groundwater levels and flat topography. These factors have affected the hydraulic and environmental performance of initial SuDS proposals, and resulted in unacceptable (i.e. un-mitigatable) flood risk impacts.

5.1.2 Departures from the SuDS design principles include: reducing the standard of attenuation, adopting SuDS within the functional floodplain but without inundation protection, adopting proprietary SuDS components as a second level of treatment and discharging to palaeochannels and minor watercourses.

5.1.3 These departures have enabled the impacts on the River Tay SAC to be minimised, by removing direct discharges into and construction activities within the SAC. Therefore, these can be considered to have increased the biodiversity benefits provided by the SuDS design. The departures have also minimised flood risk impacts by minimising the loss of floodplain storage, thereby increasing the water quantity benefits provided by the SuDS design.

5.1.4 Water quality assessment results have been undertaken which indicate that once the sensitivity of the receiving water features has been taken into consideration (Appendix A11.7), no residual significant impacts on water quality are anticipated to occur from the proposed operational discharges. The River Tay SAC catchment will benefit from the adoption of SuDS treatment in conjunction with the A9 Dualling Programme, as there is generally no such treatment associated with the existing A9.

6 References

Canadian Council of Ministers of the Environment (2011). Canadian water quality guidelines for the protection of aquatic life: Chloride. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. Available at: http://www.ccme.ca/files/Resources/calculators/WQI%20Technical%20Report%20(en).pdf.

CIRIA (2015). The SuDS Manual, C753. Woods Ballard, B., Udale-Clark, H., Illman, S., Scott, T., Ashley, R., and Kellagher, R. Available online at: https://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx

Ellis, J B., Revitt, M. and Lundy, L (2012). An impact assessment methodology for urban surface water runoff quality following best practice treatment. Science of the Total Environment vol 416, February, Elsevier BV, UK, pp. 172-179.

Environment Agency (2012). 'Preliminary Rainfall Runoff Management for Developments', rev E, W5-074/A/TR/1.

Highways Agency, Scottish Government, Welsh Assembly Government and The Department for Regional Development Northern Ireland (2009). Design Manual for Roads and Bridges Volume 11, Section 3, Part 10, HD 45/09 Road Drainage and the Water Environment.

Highways England, Transport Scotland, Welsh Government and Department for Infrastructure (2016). Design Manual for Roads and Bridges Volume 4, Section 2, Part 3, HD 33/16 Design of Highway Drainage Systems.

UK Roads Liaison Group (2013). Well-maintained Highways Code of Practice for Highway Maintenance Management [online]. Copyright of the Queen's Printer and Controller of HMSO. Available at: http://www.ukroadsliaisongroup.org/en/UKRLG-and-boards/uk-roads-board/wellmaintained-highways.cfm.

Annex 1: Water Quality Assessment Input Data

Treatment Efficiencies of SuDS Management Trains

The treatment efficiency calculation and overall treatment efficiencies of the four management train components in combination are shown below. 'The SuDS Manual' (CIRIA, 2015) guidance advises that a factor of 0.5 is applied to the treatment efficiency of a secondary treatment component, as the treatment performance of secondary or tertiary levels of treatment is reduced due to already reduced pollutant concentrations in the inflow, this is reflected in the calculations where required. Percentage (%) of Pollutant Remaining = *100% x (1 – SC1) x (1 – SC2)*

Where:

SC1 = Treatment efficiency of SuDS Component 1

SC2 = 0.5 x treatment efficiency of SuDS Component 2

Total System Treatment Efficiency (%) = 100 - % of Pollutant Remaining

Table 10: Management Train 1, 2 & 3 – summary of pollutant removal efficiencies

Drainage System	Treatment Efficiencies (%)		
	Dissolved Cu	Dissolved Zn	TSS
MT1			
SC1: Filter drain	0	45*	60*
SC2: Wetland	30***	25*	40**
Total system	*30*	*58*	*76*
MT2			
SC1: Filter Drain	0	45	60
SC2: Swale	50***	25*	30*
Total system	50	58	72
MT3			
SC1: Filter Drain	0	45	60
SC2: HVS**	0	7	20
Total system	*0*	*49*	*68*
MT4			
SC1: Filter Drain	0	45*	60*
SC2: Detention Basin	0	0	57
Total system	*0*	*45*	*71*

** Derived from Table 8.1 of DMRB HD33/16*

***Derived from Table 26.13 of The SuDS Manual C753 (CIRIA, 2015)*

****SC1 does not provide treatment, therefore treatment efficiency of SC2 not multiplied by 0.5.*

HAWRAT Method A and D Input Data

Tables 11, 12 and 13 summarise the input data used in the HAWRAT Routine Runoff and Spillage Risk calculations.

Table 11: HAWRAT and Spillage Risk Input Data (1)

Drainage Catchment	Outfall Location	Easting	Northing	AADT	Climatic Region/ Rainfall Site	Q95 Flow (m3/s)	Mean Annual Flow (m3/s)	Proposed Impermeable Area (ha)	Proposed Permeable Area (ha)
Run A1	River Tay	300442	744134	>10,000 and <50,000	Cold Wet/Ardtalnaig	33.9	139	2.214	2.434
Run A2	River Tay	300436	744684	>10,000 and <50,000	Cold Wet/Ardtalnaig	33.9	139	0.962	1.194
Run B	River Tay	300318	745943	>10,000 and <50,000	Cold Wet/Ardtalnaig	33.8	138	4.286	3.718
Run C	River Tay	300090	747749	>10,000 and <50,000	Cold Wet/Ardtalnaig	33.7	138	2.293	1.548
Run D1	WF37	299894	748281	>10,000 and <50,000	Cold Wet/Ardtalnaig	0.0009	0.0047	1.56	0.319
Run D2	River Tay	299602	748747	>10,000 and <50,000	Cold Wet/Ardtalnaig	33.5	137	2.207	2.098
Run E	River Tay	299501	749247	>10,000 and <50,000	Cold Wet/Ardtalnaig	33.4	137	1.562	0.203
Run F1	WF42	299259	750130	>10,000 and <50,000	Cold Wet/Ardtalnaig	0.0022	0.0113	1.356	0.32
Run F2	WF42	299287	750305	>10,000 and <50,000	Cold Wet/Ardtalnaig	0.0016	0.0085	0.744	0.268
Run G1	WF50	298894	750933	>10,000 and <50,000	Cold Wet/Ardtalnaig	0.0006	0.0031	1.064	2.793
Run G2	WF50	298924	750951	>10,000 and <50,000	Cold Wet/Ardtalnaig	0.0006	0.0031	1.119	0.333
Run H	WF55	298095	751551	>10,000 and <50,000	Cold Wet/Ardtalnaig	0.0013	0.0067	1.155	0.52

Table 12: HAWRAT and Spillage Risk Input Data (2)

Drainage Catchment	Existing Impermeable Area (ha)	BFI Index	Is the Discharge within 1km of Protected Site?	Water Hardness	Downstream Structure Reducing Velocity?	Estimated River Width (m)	Mannings	Side Slope	Long Slope
Run A1	0.73	0.433	Yes	Low	No	45	-	-	-
Run A2	0.41	0.433	Yes	Low	No	45	-	-	-
Run B	1.81	0.433	Yes	Low	No	47	-	-	-
Run C	0.72	0.433	Yes	Low	No	49	-	-	-
Run D1	0.70	0.681	Yes	Low	No	0.5	0.035	0.1	0.0041
Run D2	0.64	0.433	Yes	Low	No	47	-	-	-
Run E	0.77	0.433	Yes	Low	No	50	-	-	-

Drainage Catchment	Existing Impermeable Area (ha)	BFI Index	Is the Discharge within 1km of Protected Site?	Water Hardness	Downstream Structure Reducing Velocity?	Estimated River Width (m)	Mannings	Side Slope	Long Slope
Run F1	0.61	0.71	Yes	Low	Yes	9	-	-	-
Run F2	0.22	0.71	Yes	Low	Yes	18	-	-	-
Run G1	0.38	0.71	Yes	Low	Yes	0.5	0.035	0.1	0.0203
Run G2	0.47	0.71	Yes	Low	Yes	0.5	0.035	0.1	0.0203
Run H	0.66	0.688	Yes	Low	Yes	18	-	-	-

Table 13: HAWRAT and Spillage Risk Input Data (3)

Drainage Catchment	Proposed SuDS Treatment Train	Proposed treatment of Cu (%)	Proposed treatment of Zn (%)	Proposed settlement of sediments (%)	Restricted Discharge Rate from SuDS Outfall (l/s)	Attenuation Achieved	Breakdown of Road Lengths Draining to Outfall
Run A1	MT1: Filter Drain and Wetland	30	58	76	26.0	200 Yr + CC (GF)	Mainline - CH. -10 - CH. 778 Tie-in (roundabout) - CH. 600 - CH. 680
Run A2	MT1: Filter Drain and Wetland	30	58	76	10.3	200 Yr + CC (GF)	Mainline - CH. 778 - CH. 1225
Run B	MT3: Filter Drain and HVS	0	49	68	50.9	30 Yr + CC (BF)	Mainline - CH. 1225- CH. 3150
Run C	MT4: Filter Drain and Detention Basin	30	59	76	16.2	200 Yr + CC (GF)	Mainline - CH. 3150 - CH. 3950 Rotmell Junction - CH. 90 - CH. 185
Run D1	MT2: Filter Drain and Swale	50	58	72	8.3	30 Yr + CC (BF)	Mainline - CH 3950 - CH. 4640 Dowally Farm Access Road - CH. 200 - CH. 430
Run D2	MT2: Filter Drain and Swale	50	58	72	18.8	30 Yr + CC (BF)	Mainline - CH. 4640 - CH. 5350 Dowally - Guay Link Road - CH. 0 - CH. 300
Run E	MT1: Filter Drain and Wetland	30	58	76	12.1	30 Yr + CC (BF)	Mainline - CH. 5350 - CH. 6050 Dowally to Kindallachan Side Road - CH. 1210 - CH. 1790 Kindallachan Direct Access- CH. 0 - CH. 77
Run F1	MT3: Filter Drain and HVS	0	49	68	9.3	30 Yr +CC (BF)	Mainline - CH. 6050 - CH. 6600
Run F2	MT3: Filter Drain and HVS	0	49	68	3.8	30 Yr +CC (BF)	Mainline - CH. 6600 - CH. 6950
Run G1	MT3: Filter Drain and HVS	0	49	68	12.0	30 Yr + CC (BF)	Mainline - CH. 6950 - CH.7325
Run G2	MT3: Filter Drain and HVS	0	49	68	6.0	30 Yr + CC (BF)	Mainline - Ch. 7325 - CH.7790
Run H	MT1: Filter Drain and Wetland	30	58	76	6.6	30 Yr + CC (BF)	Mainline - CH. 7800 - CH. 8230 Cuil-an-Duin Access Road - CH. 0 - CH. 282